The Increasing-Returns-to-Scale/Sticky-Price Approach to Monetary Analysis

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A new approach to the analysis of the effects of monetary policy on economic activity is developing. Its pioneers are Benhabib and Farmer (1992) and Beaudry and Devereux (1993, 1995). The combined assumptions of increasing returns to scale (IRS) in production and sticky prices identify this approach.[1] The goal is to rationalize slow price adjustment in response to monetary shocks and, consequently, strong and persistent real effects of monetary policy in a fashion consistent with market clearing.

The IRS/sticky-price theory is new, ambitious, and exciting. The traditional approach to sticky prices of the type advanced by Phelps and Taylor (1977) and Fischer (1977) assumes (with no attachment to IRS) that prices are preset for a certain period of time. Thus, when new information on economic conditions arises that was unanticipated when prices were set, those prices are necessarily inconsistent with full optimization on the part of all agents and hence with market clearing. Furthermore, the real effects of money shocks are of short duration, stemming from the short period over which prices are preset. The inconsistency with market clearing and the lack of persistence in the real effects of money are widely viewed as significant weaknesses in the traditional theory. The new theory comes to grips with both of these weaknesses. In striking contrast to the traditional theory, the IRS/sticky-price theory explains how prices are free

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[1] Strictly speaking, the Benhabib and Farmer (1992) model does not maintain IRS in production. Instead, firms' production functions are influenced by an externality factor that depends on the economy's real money balances. This externality factor, like IRS, causes equilibrium indeterminacy, creating the avenue for introducing sticky prices and propagating the effects of monetary shocks. For this reason, the Benhabib and Farmer study is included among those forming the new approach. Moreover, Farmer (1993) views the monetary externality as a proxy for IRS in production.

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to change sluggishly over time. The explanation is consistent not only with optimization by all agents and market clearing but also with prolonged real effects from money. Also, the IRS/sticky-price theory marks initial progress in incorporating monetary policy into the recent prominent research area featuring the importance of IRS for explaining business-cycle fluctuations (see, for example, Rotemberg and Woodford [1995] for a review of this research).

The essential ideas of the IRS/sticky-price theory may be described as follows: IRS amplify the economy's response to shocks arising from any source. When large enough, IRS cause the economy's equilibrium to become indeterminate. The assumption of sticky prices resolves this indeterminacy, and in doing so, perhaps surprisingly, allows markets to clear. The combination of the assumptions of IRS and sticky prices is a powerful force that produces slow price adjustment and, therefore, significant as well as prolonged nonneutral effects from money shocks.

The purpose of this article is to access and to explain, as nontechnically as possible, the ideas of the IRS/sticky-price theory.[2] The discussion focuses only on the Beaudry and Devereux (1995) model (the BD model).[3,4] Not only is the BD model representative of the models in its class, but its quantitative implications have been the most fully developed, which enables it to be evaluated in terms of its ability to explain empirical evidence.

The remainder of the article is organized as follows: Section 1 considers the assumption of IRS, Section 2 discusses the sticky price assumption, Section 3 explains how sluggish price adjustment and monetary nonneutrality occur, Section 4 compares the IRS/sticky-price theory's predictions with the facts, and Section 5 presents some conclusions.

1. THE ASSUMPTION OF INCREASING RETURNS TO SCALE

IRS, which work through an externality factor in the individual production functions of firms that produce intermediate goods, magnify the parameters in the relationship between aggregate final output and the aggregate amounts of factors of production. In so doing, they amplify the response of output to the fluctuations in productive factors that are induced by exogenous shocks. To see more exactly how IRS work, consider the following: an intermediate

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[2] The article draws partly on the author's discussion in Finn (1995). See Salyer (1995) for a review of IRS models that do not have money or sticky prices.

[3] The models in the studies forming the new approach, listed in the text, do differ in specification, including the dimensions involving IRS and the transactions role of money. But the logic of the explanations and assessments presented in the article easily extends to those models.

[4] There are two perfectly symmetrical economies in the BD model. For simplicity of exposition, this article's discussion pertains to one of these economies.

goods firm produces a unique intermediate good i according to the production function F:

$$x_i = F(k_i, l_i, \Lambda) = k_i^\alpha l_i^{(1-\alpha)} \Lambda \quad , \quad 0 < \alpha < 1, \tag{1}$$

where x_i is the output of intermediate good i, $k_i(l_i)$ is the input of capital (labor) into the production of intermediate good i, Λ is the externality factor, and α is a parameter. (For simplicity, fixed costs of production and imported capital, present in the BD model, are ignored here.) F exhibits constant returns to scale with respect to the individual firm inputs, k_i and l_i. The externality, exogenous to the individual firm because it depends on aggregate economic activity, is determined by

$$\Lambda = [K^\alpha L^{(1-\alpha)}]^{\gamma - 1} \quad , \quad \gamma > 1, \tag{2}$$

where K and L are the aggregate amounts of k_i and l_i, respectively, employed in the economy, and γ is the IRS parameter. The number of intermediate goods firms measures unity so that aggregate input equals per-firm input of each factor of production. Intermediate firms' output is combined by many final goods firms to produce the final good. The production function linking the aggregate output of the final good, denoted by X, to intermediate goods is

$$X = [\int x_i^\rho di]^{1/\rho} \quad , \quad 0 < \rho < 1, \tag{3}$$

where ρ is a parameter determining the elasticity of substitution in production between the intermediate inputs $1/(1 - \rho)$. The relationship in equation (3) displays constant returns to scale.

In equilibrium, all intermediate goods firms behave identically. That is, they employ identical amounts of the factors of production which, as mentioned above, coincide with K and L; and they produce the same amount of output, denoted by x. Noting these results in equations (1) through (3), it follows that in equilibrium the relationship between aggregate final output and aggregate factors of production is

$$X = x = F(K, L, \Lambda) = K^\alpha L^{(1-\alpha)} \Lambda = [K^\alpha L^{(1-\alpha)}]^\gamma. \tag{4}$$

Since $\gamma > 1$, this relationship shows IRS. The IRS can now be seen to work through the externality factor, Λ, to increase the parameters linking aggregate final output, X, to each of the aggregate factors of production, K and L. Accordingly, X is more responsive to K and L than it otherwise would be. Two important issues arise.[5]

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[5] Beaudry and Devereux (1993) assume that IRS are internal to the individual intermediate goods firm. The internal IRS, just like the external IRS, work to magnify the parameters linking X to K and L. Benhabib and Farmer (1992) do not assume IRS in production. Individual firm production functions are affected, though, by an externality factor, depending on the economy's real money balances (see footnote 1 for more detail). The essence of the two discussion issues, following in the text, applies to Beaudry and Devereux (1993) and Benhabib and Farmer (1992).

Why IRS?

What explains the existence of an externality factor in individual firms' production functions that depends on aggregate economywide employment of capital and, especially, of labor?[6] For instance, how could an increase in labor employment by a motor engine-producing firm simultaneously enhance productivity in a paper-producing firm? The studies forming the IRS/sticky-price approach provide no discussion of these questions.

The most obvious possible answer invokes the learning-by-doing idea (Arrow 1962). According to this idea, the people involved in any production activity learn more efficient ways of doing it. Sometimes such learning is easily disseminated and applied to other production activities. When this happens, the higher the aggregate production activity in the economy, the higher the productivity/efficiency of any individual firm's production method. But learning-by-doing tends to occur and is disseminated fairly slowly over time. Hence, it is better captured by an externality factor that depends on the economy's slowly changing aggregate capital stock than by one that depends on the economy's quickly changing aggregate labor employment. That is, it is difficult to see how learning-by-doing would lead to the magnification of labor input's exponent in the aggregate production function.

Future research may provide a clear-cut answer to the above question. It is an important one, and an answer seems necessary before confidence can be placed in the IRS/sticky-price approach to analyzing monetary policy. That approach hinges sensitively on the size of labor's exponent in the aggregate production function, which will be explained next.

The Importance of the Magnitude of IRS

The IRS/sticky-price theory of the effects of monetary shocks crucially depends on the size of the IRS parameter, γ. Two points are at stake. First, γ must be sufficiently big to cause equilibrium indeterminacy. It is only when indeterminacy arises that the sticky price assumption can be made, thereby rendering the equilibrium determinate. Furthermore, sticky prices are at the source of the powerful nonneutral effects of monetary shocks. Second, γ must not be too big because, for high values of γ, the volatility of real variables is decreasing in the magnitude of γ. Thus, the nonneutral effects of monetary shocks diminish as γ rises. These two points are more fully explained in this section.

An essential component of the IRS/sticky-price theory is that equilibrium is indeterminate prior to imposing the sticky price assumption. A necessary condition for this indeterminacy is that, at the level of the aggregate economy,

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[6] Prescott (1989) raises questions and arguments similar to those presented here.

labor's marginal productivity is increasing in labor. That is, the production function in equation (4) must satisfy the parametric restriction

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\begin{aligned}
(1 - \alpha)\gamma > 1 \qquad &\text{or} \\
\gamma > \underline{\gamma} \equiv 1/(1 - \alpha).&
\end{aligned}
\tag{5}
$$

Strong empirical evidence gives a value for labor's output share, $(1 - \alpha)$, that is close to 0.70 (see, for example, Lucas [1990]). Using 0.70 as an example, the condition in equation (5) is $\gamma > \underline{\gamma} = 1.43$.

Some intuition for the necessity of rising marginal labor productivity is obtained by following the BD model in considering behavior in the labor market under two alternative assumptions regarding (aggregate) returns to scale—IRS and constant returns to scale (CRS). Figure 1 shows the labor market situation for both cases.

The labor supply curve, L^s, reflects agents' desire to provide an amount of labor ensuring equality between the real wage W/P and the marginal rate of substitution between leisure and consumption. An increase in W/P, which represents the opportunity cost of leisure in terms of consumption, generates a substitution effect away from leisure and toward labor, output, and consumption. Therefore, L^s is positively sloped and as labor rises along L^s, so does consumption. One important variable that can shift L^s is investment. In particular, an increase in investment, by setting in motion a force to sharply reduce the amount of output available for consumption, operates on labor incentives analogously to a negative wealth effect. Thus, at any given real wage rate, an increase in investment is accommodated by a rise in labor and output and a mitigated decline in consumption. Graphically, investment increases shift L^s to the right, and as it does, at any given real wage, consumption falls.[7]

The labor demand curves are L_c^d and L_I^d under the assumption of CRS and IRS, respectively. Both curves capture firms' decisions to hire labor up to the point that equates labor's marginal product to the real wage. With CRS (i.e., $\gamma = 1$ in equation [4]), the marginal productivity of labor is declining in labor, giving L_c^d its negative slope. But with sufficiently high IRS (i.e., γ satisfying equation [5]), labor's marginal productivity increases with increases in labor, imparting a positive slope to L_I^d.

Initially, the labor market is in equilibrium at E. Now consider an experiment in which firms suddenly wish to increase investment even though nothing fundamental has changed. The question is whether this desired increase in investment could be supported by a new equilibrium that is different from E. An increase in investment would shift L^s to the right, say to $L^{s'}$, giving rise

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[7] If the marginal utility of leisure is a constant (invariant to the level of leisure) then, at any given real wage, consumption will stay constant as investment increases. In that case, at any given real wage, labor rises enough to cause output increases that exactly match the increases in investment.

Figure 1　Labor Market with IRS and CRS
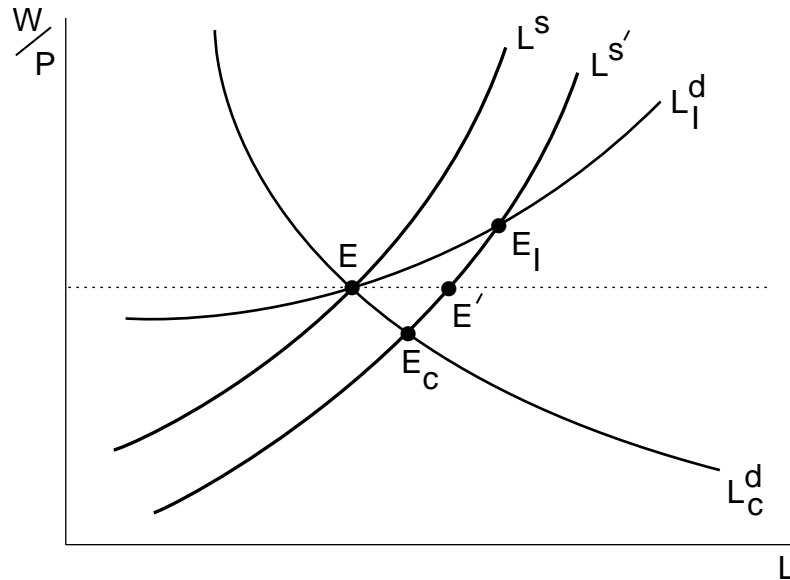
to the intersection points E', E_c and E_I. Consumption is lower at E_c than at E (because consumption is lower at E_c than at E' and lower at E' than at E). This lower consumption would be consistent with a new equilibrium at E_c only if the real interest rate were higher at E_c than at E; a rise in the real interest rate reduces consumption because of intertemporal substitution. But any such rise in the real interest rate would quench the initial desired investment increase. Consequently, the CRS economy has a unique equilibrium at E. For the IRS economy, the situation is different. Consumption is higher at E_I than at E. (L_I^d is assumed to be sufficiently upward sloping so that the rise in consumption from E' to E_I dominates the fall in consumption from E to E'.) This higher consumption would be consistent with a new equilibrium at E_I if the real interest rate were lower at E_I than at E. A decline in the real interest rate operates to validate the desired increase in firms' investment. Thus, the IRS economy could achieve a new equilibrium at E_I. Multiple equilibria are possible for the IRS economy: the IRS economy's equilibrium is indeterminate.

The second point about the size of γ is that it must not be too big, because in the range satisfying equation (5), the volatility of real variables is decreasing in the size of γ (Beaudry and Devereux, Tables 2 and 3). Intuitively, increases in γ exert two opposing forces on volatility. First, for any given change in the amounts of employed capital and labor, a rise in γ implies a larger change

in output and, hence, in most other real variables, such as consumption and investment. Second, when γ satisfies equation (5), a higher value of γ causes the aggregate marginal productivity of labor to rise more quickly with any increase in labor. Consequently, smaller changes in labor and hence in capital, output, and most other real variables are needed to equilibrate the economy in response to a shock. The second force is the dominant one (again when γ satisfies equation [5]), so the volatility of real variables decreases as γ decreases.

The result of the two points concerning the magnitude of γ is that the IRS/sticky-price theory requires γ to lie in a narrow range above $\underline{\gamma}$. This outcome is somewhat troubling for the theory, at least given the current state of knowledge. Existing empirical evidence is far from precise. Studies by Hall (1990), Caballero and Lyons (1992), Eden and Griliches (1993), Basu and Fernald (1994), and Burnside, Eichenbaum, and Rebelo (1995) give point estimates of γ ranging from one to ten. But perhaps by being explicit about the microtheoretic foundations of IRS, future research will develop more precise estimates of γ or will extend the theory in a way that lessens its dependence on the size of γ.

2.   THE STICKY PRICE ASSUMPTION

Once indeterminacy of equilibrium arises because of IRS, the assumption of sticky prices is made to eliminate that indeterminacy. Alternatively viewed, the sticky price assumption selects one of the multiple equilibria engendered by IRS. This section provides an intuitive explanation of how sticky prices achieve determinacy of equilibrium and discusses two characteristics of this particular approach to sticky prices.[8]

The intermediate goods market is monopolistically competitive. Each intermediate goods firm chooses the optimal price of its good each period according to the constant markup rule

$$p_t = (1/\rho)MC_t \quad , \quad MC_t = \frac{[\hat{R}_t^{\alpha}\hat{W}_t^{(1-\alpha)}]A}{\Lambda_t} \quad , \quad A > 0, \qquad (6)$$

where p is the nominal price of any intermediate good, MC is the nominal marginal cost of producing any intermediate good, $\hat{R}$ is the nominal rental price of capital that firms pay, $\hat{W}$ is the nominal wage of labor faced by firms, A is a parameter, and subscript t denotes time. The marginal cost is increasing in an index of factor prices and decreasing in the externality factor that enhances the productivity of firm inputs. Noting that the absolute value of the

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[8] The discussion in this section extends easily to Beaudry and Devereux (1993), where IRS are internal to firms, and to Benhabib and Farmer (1992), where the production externality is a monetary one and where firms are perfectly competitive price takers.

price elasticity of demand for intermediate goods (by final goods firms) is the same as the elasticity of substitution of intermediate goods, $1/(1 - \rho)$, and is thus increasing in ρ, equation (6) shows that the markup is inversely related to that price elasticity. Equation (6) also shows that all intermediate goods firms choose the same price because marginal cost is identical across firms.

The final goods market is perfectly competitive. There, because final goods firms choose their optimal output each period, the nominal price of the final good, denoted by P_t, always equals the nominal marginal cost of its production, which can be shown to equal p_t. Therefore

$$P_t = p_t. \tag{7}$$

The sticky price assumption imposes the requirement that P_t is unresponsive or rigid with respect to any new information that becomes available at time t. That is, P_t is assumed to be predetermined at time t. Following equations (6) and (7), p_t and MC_t must also be predetermined at time t. Thus, with the sticky price assumption in place, any unanticipated movement in the externality factor at time t, Λ_t has to be matched by an equal movement in the factor price index, $[\hat{R}_t^{\alpha} \hat{W}_t^{(1-\alpha)}]$ to keep equation (6) intact. This also means that real return to capital, or the real interest rate, rises at time t if an unanticipated expansionary force increases the economy's output, and thus Λ, at time t. One example of such an unanticipated expansionary force is the sudden desire to increase investment that was considered in the experiment of Section 1. Rerunning that experiment for the IRS economy under conditions of sticky goods prices shows that the desired investment increase is vitiated by the increase in the real interest rate. Therefore, the IRS economy with sticky prices has a unique equilibrium. The assumption of sticky prices is responsible for ensuring the determinacy of equilibrium.

A unique feature of the sticky price assumption is that it is made at the last stage of the modeling procedure. All other assumptions (for instance, those describing preferences, production technologies, and market structure) are made, in standard fashion, at the beginning of the model specification. Next, the equations defining the economy's equilibrium are deduced. If that equilibrium is indeterminate, the last step of the modeling process is to obtain determinacy of equilibrium by making the sticky price assumption. This unique feature is important for at least two reasons.

First, to arrive at the point of assuming sticky prices, the economy's structure must give rise to equilibrium indeterminacy. This is somewhat of a drawback because the required structure is not necessarily easy to justify on theoretical and empirical grounds. In the IRS/sticky-price theory case, a strong stand needs to be taken on the nature and magnitude of IRS, as discussed earlier.

Second, the approach to sticky prices described above is consistent with all firms optimizing and, consequently, with market clearing. This aspect is

appealing. As mentioned before, all firms choose plans that maximize profit every period. In particular, intermediate goods firms always choose their prices according to their optimal markup pricing rule (equation [6]). By imposing sticky prices on those optimization rules, optimization continues to hold. Curiously, one may imagine, even though it is not literally true, that the intermediate goods firms are choosing prices one period in advance (i.e., choosing p_t at time $t-1$), because firms never want to adjust p_t to information that is new at time t.

This approach to sticky prices sharply contrasts with the approach taken in traditional macroeconomic models (e.g., Phelps and Taylor [1977]; Fischer [1977]). The traditional approach does not require initial equilibrium indeterminacy, and it is inconsistent with full optimization and market clearing. In that approach, by assumption, prices truly are set in advance. Consequently, when new, unanticipated information on demand and supply conditions emerges, those prices are inconsistent with all agents optimizing and thus with market clearing.

3.   SLUGGISH PRICE ADJUSTMENT AND MONETARY NONNEUTRALITY

The combination of the IRS and sticky price assumptions acts as a powerful force to engender sluggish price adjustment and, therefore, monetary nonneutrality. To explain how this force operates, this section analyzes the effects on the economy of a permanent increase in the money stock.[9]

The fundamental role of money is to mitigate the transactions costs arising from the process of allocating factors of production to production activity. More exactly, the transactions costs are increasing in the economy's employment of capital and labor and decreasing in real money balances as captured by the relationship

$$\phi(N/P, X) = B(N/P)^{(1-\nu)}X^\nu \quad , \quad B > 0 \quad , \quad \nu > 1, \tag{8}$$

where ϕ is transactions costs (measured in units of output), N is the money stock, B and ν are parameters, and X is directly related to factor employment

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[9] The main modification required to apply this explanation to Beaudry and Devereux (1993) is simply to recognize the different transactions role for money in that study. The consequential different effect of a permanent money stock increase is that nominal interest rates fall in Beaudry and Devereux (1993) while they stay approximately constant in the BD model. The explanation of monetary nonneutrality is quite different across the BD and Benhabib and Farmer (1992) models, primarily because the production externality is monetary (and not real) in nature and there is no investment in the latter model. The important point common to both explanations is that the production externality ensures that the money supply increase leads to such a sizable expansion of output (at predetermined current prices) and the real demand for money that money market equilibrium is reestablished by tiny and sluggish increases in future price inflation.

according to equation (4). Because of these transactions costs, households re-
ceive payments for providing factor services that fall short of the marginal
productivities of those services. In fact, it is straightforward to show that the
factor prices received by households are

$$W = MC(MP_L)[1 - \phi_2(N/P, X)] \text{ and} \tag{9}$$

$$R = MC(MP_K)[1 - \phi_2(N/P, X)], \tag{10}$$

where W is the nominal wage of labor received by households; R is the rental
price of capital received by households; MP_L and MP_k are the marginal pro-
ductivities of L and K in producing the output of the typical intermediate goods
firm; ϕ_2, the marginal transactions cost of increasing output, denotes the partial
derivative of ϕ with respect to X. Equations (9) and (10), together with the
properties of ϕ_2, make clear that transactions costs shrink the value of factor
payments to households while money holdings help mitigate the extent of that
shrinkage.

   If the monetary authority permanently increases the money stock at time
t, what will happen at time t? With P_t predetermined at time t, by assumption,
the effect of a rise in N_t is a proportionate rise in N_t/P_t. Consequently, the
marginal transactions cost of hiring all factors in goods production falls (i.e.,
ϕ_2 declines), implying an increase in W_t and R_t (see equations [9] and [10]).
This increase in factor payments invokes a rise in households' desire to supply
factors to intermediate goods firms. The firms willingly hire the desired increase
in factor supply—in a sense they are indifferent because, as explained earlier,
both the price and marginal cost of their goods stay constant. The resultant
increase in K_t and L_t expands the output of all goods; thus, X_t rises. On the
opposite side of the supply response is the demand response. The increase
in N_t/P_t, by raising household wealth, causes an expansion in spending for
both consumption and investment purposes. Denoting aggregate consumption
and investment of the final good by C_t and I_t, respectively, the rise in X_t
is absorbed by the rise in C_t and I_t. Because of the presence of IRS, all of
these expansions in factor employment, output, consumption, and investment
are sizable. Furthermore, IRS together with the large increase in (I_t implies that
all of these real expansionary effects are strongly propagated into the future.

   The sticky price assumption makes current prices predetermined only at
time t. Future prices are perfectly free to respond to the money supply increase,
starting from time $(t + 1)$. But they do so gradually, and P_{t+1} responds hardly
at all. P_{t+1} is essentially determined by its role in ensuring equilibrium in the
money market at time t. The money market equilibrium condition is

$$N_t/P_t = G(X_t, i_t) \quad , \quad G_1 > O \quad , \quad G_2 < 0, \tag{11}$$

where G is a function, G_j is the first derivative of G with respect to its jth
argument, $(j = 1, 2)$, and i_t is the net nominal interest rate. This condition

sets money demand equal to money supply. Stemming from the role of money in alleviating the transactions costs arising in production activity, real money demand is increasing in X_t. The opportunity cost of money is the forgone nominal interest rate on bonds and so the demand for real money balances is declining in i_t. Equation (11) captures both of these effects on real money holdings. Furthermore, an intertemporal efficiency condition governing optimal nominal (discount) bond holdings in the economy gives rise to the equilibrium asset-pricing relationship

$$(1 + i_t) = \left(\frac{P_{t+1}C_{t+1}}{P_tC_t}\right)\beta^{-1}. \tag{12}$$

The gross nominal interest rate at time t is the product of price inflation and consumption growth between time t and time $(t+1)$ and the reciprocal of the subjective discount factor β.[10]

   While P_{t+1} can in principle respond to the increase in N_t, there are two reasons why its response is negligible. First, the expansion of X_t is large enough relative to that in (N_t/P_t) to create a small incipient excess demand for real balances. Second, the strong increase in I_t propagates the increase in X_t so strongly into the future that consumption grows slightly for a time. The small increase in C_{t+1}/C_t causes a small rise in i_t that is sufficient to eliminate the incipient excess demand for money. Consequently, P_{t+1} does not need to change significantly.

   IRS and capital accumulation act to strongly propagate, though at a diminishing rate, the real expansionary effect of the money supply increase well into the future. Similar reasoning explains that prices at time $(t+2)$ and beyond are also slow to change. It is only after about four periods (at time $t+4$), as consumption growth slows and becomes negative, that P eventually and slowly increases. At any time, the increase in future P keeps i approximately constant in face of the small negative consumption growth rates because an approximately constant i is sufficient to ensure money market equilibrium. Meanwhile, the increase in current P engineers the reductions in N/P that, each period, closely match the declines in X as the economy returns to its steady state. In the steady state, all real variables take on their original values—their values prior to the increase in N_t—and P rises in the same proportion as N_t. That is, the steady state is neutral with respect to the increase in N_t. Thus, the sluggish price adjustment and consequential monetary nonneutrality are short-run phenomena.

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[10] The utility function here is assumed to be an additively separable and logarithmic function of consumption. Also, for simplicity, the expectations operator is omitted.

4. EXPLAINING THE FACTS

How well does the IRS/sticky-price theory explain the empirical evidence? To address this question, this section evaluates the theory along four key dimensions—price, output, nominal interest rate responses to monetary shocks, and the correlation between productivity and employment.

Sluggish Price Adjustment

Empirical evidence indicates that the price level exhibits a slow and lengthy response to monetary innovations.[11] The theory well captures this evidence. However, it is not entirely clear that the theory's ability to mimic the data along this dimension should be viewed as an explanation. By assumption, prices cannot contemporaneously respond to monetary shocks. Furthermore, the endogenous propagation mechanism delivers sluggish price adjustment in such a direct fashion that it is almost tantamount to building in sluggish price adjustment over time by assumption. Admittedly this is somewhat of a fine point, but it does, at least, prompt less serious evaluation of the theory along the sluggish price dimension and more serious evaluation along other dimensions.

Output Response

Stemming primarily from the assumptions of IRS and sticky prices, the BD model has strong implications for the magnitude of the output response to a money shock.[12] For example, the model implies that a 1 percentage point increase in the money stock contemporaneously causes a 7 percentage point rise in real output. An output response of this magnitude seems much too big. Sims's (1980) evidence for the U.S. economy over the postwar period shows that a 1 percent money stock innovation within the same period causes only a 0.42 percent increase in output. Part of the model's excessive contemporaneous output response may be due to the manner in which IRS works. Specifically, by magnifying labor's exponent in the production function, IRS permits the economy to instantly and significantly respond to shocks from any source.

Nominal Interest Rate Response

As described earlier, the BD model predicts essentially no nominal interest rate response to monetary shocks, which seems counterfactual. Strong evidence documents the liquidity effect—the negative effect on nominal interest rates exerted by positive monetary innovations (Cochrane 1989). However, the

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[11] See, for instance, Sims (1980, 1989) for evidence pertaining to the United States.

[12] This is also true of the Beaudry and Devereux (1993) model. The same strong implications hold for the Benhabib and Farmer (1992) model, but in that case they stem from the assumptions of the monetary externality and sticky prices.

model's prediction along this dimension is not necessarily a prediction of the IRS/sticky-price theory generally. In particular, for a slightly different specification of the transactions role of money in Beaudry and Devereux (1993), the liquidity effect is indeed predicted.

Employment-Productivity Correlation

The IRS/sticky-price theory crucially rests on IRS as the cause of increasing marginal productivity of labor.[13] This phenomenon, in turn, implies that labor and its productivity should always move in the same direction. In fact, they do not. At business-cycle frequencies the correlation between labor and its productivity is close to zero (Christiano and Eichenbaum 1992). This inconsistency between the theory and the facts is important.[14] Just like the inconsistency involving the output response, it seems to underscore the importance of developing the microtheoretic foundations of IRS.

5. CONCLUSION

The IRS/sticky-price theory is a new approach to the analysis of the effects of monetary policy on the economy. Its goal is to explain, within a market-clearing framework, why prices are slow to respond to monetary shocks and, therefore, why monetary shocks can have strong real effects. Several key points are explained and assessed in this article.

First, it is not clear how IRS can in principle be justified, especially as it pertains to labor input into production. Also, existing empirical estimates do not provide solid support for placing the magnitude of IRS into the narrow range required for the theory to work. To be convincing, the IRS/sticky-price theory needs to address both of these issues. Perhaps by making explicit the theoretical foundations of IRS, future research will develop a theory that lessens its dependence on the precise magnitude of IRS or else will provide estimates that support the theory as it now stands.

Second, a fine line exists between viewing the IRS/sticky-price theory as explaining or assuming the slow adjustment of prices in response to monetary shocks. By assumption, prices are sticky; that is, they cannot contemporaneously respond to shocks. While prices are free to respond over time, the endogenous propagation mechanism produces slow price adjustment in a direct fashion—so much so that it comes close to assuming a slow price response. The existence of this fine line makes it important to evaluate the theory along dimensions different from sluggish price responses to money shocks.

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[13] It is not clear whether the Benhabib and Farmer (1992) model incorporates increasing marginal productivity of labor.

[14] Prescott (1989) points out the same inconsistency.

Third, in its current state, the IRS/sticky-price theory predicts huge output responses to monetary shocks and correlations between labor and its productivity that are noticeably counterfactual. This inconsistency between the theory's predictions and the facts underscores the importance for the theory to develop the theoretical rationale for IRS.

The IRS/sticky-price theory is innovative and ambitious in tackling the difficult issue of explaining the effects of money on the economy. The points raised in this article suggest, on the one hand, that it would be premature to use this theory as a basis for understanding the monetary transmission mechanism. In particular, the theory is too inconsistent with key facts to be useful for that purpose. On the other hand, the article suggests that it may be fruitful to explore this theoretical approach further by developing the theory underlying IRS.

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